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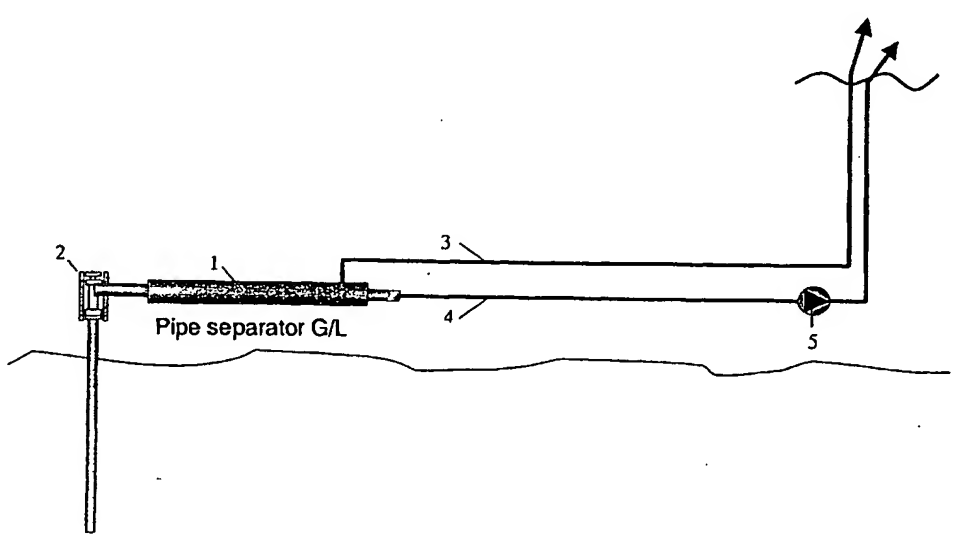
(54) Title: AN INSTALLATION FOR THE SEPARATION OF FLUIDS



(57) Abstract: An installation arranged on the sea bed for the separation of fluids, comprising at least one separator (1) that is connected to one or more wells, each via an associated well head (2) or similar, and a pipeline (17). The components separated, oil, gas, water or combinations of these substances, are fed fully or partially from the installation to a platform, vessel, etc. on the surface or via collecting pipelines onto shore, or are reinjected into the formation beneath the sea bed. Each separator (1) consists of a long pipe (pipe separator) that may form a major or minor part of the transport pipeline (18) from the well and has a diameter that is mainly equal to or slightly larger than the diameter of the transport pipeline (18).

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An installation for the separation of fluids

The present invention concerns an installation arranged on the sea bed for the separation of fluids.

Fluids in this context means oil, gas and water or mixtures of these substances, possibly containing particles of sand, that are produced in connection with the extraction of oil/gas from wells in geological formations beneath the sea bed.

PCT/NO98/00085 concerns the separation of fluids in pipe separators in horizontal sections of wells.

The main reason why it is possible to achieve quantitative oil and water separation in a pipe separator installed in a horizontal well is related to the good separation properties of the well fluid. The main reason for the good separation properties in the well is that the interface between the oil and water is relatively free of surfactants that can stabilise the interface and thus impede drop growth and the formation of a free aqueous phase in connection with coalescence. This is what makes it possible to use such separation solutions in the well, where controlled use of a de-emulsifier is very complicated or virtually impossible.

In many cases, it may be desirable to carry out the separation on the sea bed instead of in the wells. On the sea bed, chemical destabilisation of the crude oil using a de-emulsifier is a much simpler and absolutely realistic solution. Chemical destabilisation of the fluid can improve the separation properties of the fluid so that they are almost as good as down-hole conditions. This makes it possible to use pipe separator technology on the sea bed in connection with sea bed processing plants. With a sea bed installation, there is also greater freedom with regard to the choice of separator diameter than with a down-hole installation.

Conventional gravitation separators are characterised by large tank diameters. This limits the application of the technology to relatively shallow waters. Long, thin separators with high L/D ratios are favourable for use at large sea depths.

Under typical sea bed conditions, the separation properties of the oil/water fluid will always be poorer than under down-hole conditions. This difference can be compensated for by placing the separator upstream of the choke when using a de-emulsifier or ultrasound. This makes it possible to use pipe separators on the sea bed. In practice, the pipe separator can be a transport pipeline designed with a slightly larger diameter than necessary or as an extended section of the transport pipeline. The pipe separator is an effective solution to the design problem caused by high external liquid pressure at large sea depths. The technology can be combined with CEC (Compact Electrostatic Coalescer) concepts based on pipe coalescers, which allows it to be used at larger sea depths. For fluids that are more difficult to separate, a CEC is necessary to achieve the product specifications of the oil phase and to eliminate downstream hydrate precipitation problems in this flow.

The advantages of using a pipe separator in a sea bed processing plant are, among other things, that it allows:

- bulk gas/oil/water separation
- removal of water from crude oil to product specifications
- purification of production water to a quality that allows reinjection
- purification of production water to a quality that allows it to be discharged
- chemical-free hydrate control in connection with the transport of crude oil and gas.

In the main, the pipe separator produces bulk oil/water separation. For lighter, simpler crude oil systems, the separator will be able to separate the fluid down to product specifications. In this case, no further separation unit is required in the process. The

pipe separator is designed as follows. The last part of the transport pipeline from the well head to the processing template is designed as a long, thin pipe separator. On account of its small pipe diameter (in the order of 0.5 m), the separator can be operated at high extemal pressure and low internal pressure. The separator is therefore particularly well suited for large sea depths. It is important for the water quality from the separator to be as good as possible in order to avoid, as far as possible, any further purification before injection/discharge. The separator can therefore be fitted with a mechanical ultrasound-based emulsion destabilisation system instead of using a chemical de-emulsifier. This solution will be able to produce a water quality that is suitable for reinjection (<< 1000 ppm) and possibly for discharge into the sea (< 40 ppm). A particularly favourable position for the pipe separator will be at the well head before any pressure relief.

The separator is designed as a three-phase separator with configuration options that allow for separate removal of gas, oil and water or, alternatively, gas/oil as a common flow and water as a separate flow. In addition, it must also be possible to design the separator as a two-phase oil/water separator for use downstream from a CEC (Compact Electrostatic Coalescer).

The separator can be fitted with an ultrasound-based destabilisation system for the emulsion layer at the oil/water interface (as an altemative to the use of chemicals to break up emulsions). The separator is also fitted with a double set of level profile meters (altematives: gamma, capacitance and ultrasound). The end of the pipe separator is connected to the template either directly or via flexible hoses.

The present invention will be described in further detail in the following by means of examples and figures, where:

Figure 1 shows an installation on the sea bed with a pipe separator for gas/liquid separation.

Figure 2 shows a first alternative embodiment of an installation with a pipe separator for gas/oil/water separation.

Figure 3 shows a second alternative embodiment of an installation with two pipe separators in series, the first for gas/liquid separation and the second for oil/water separation.

Figure 4 shows a third alternative embodiment of an installation with a pipe separator for gas/oil/water separation followed by a compact electrostatic coalescer and subsequently a pipe separator for oil/water separation.

Figure 5 shows a fourth altemative installation with a pipe separator for gas/oil/water separation followed by a compact electrostatic coalescer and subsequently a pipe separator for oil/water separation. In addition, there is a gas dehydration unit consisting of a pipe contactor and a gas/liquid separator in connection with the first pipe separator.

Figure 6 shows a fifth embodiment which is based on the solution shown in Figure 4, but which is adapted for situations in which two or more wells produce different quantities of oil/water/gas.

Figure 1 shows an installation arranged on the sea bed with a separator in the form of a pipe (pipe separator) 1 for gas/liquid separation that is connected to a well head 2. This is a simple solution designed for use for oil/gas wells in which small quantities of water are produced. The separated gas is removed in a pipe 3 and fed up to a platform, a production ship, etc. on the surface of the sea or a collecting pipeline that feeds the gas onto shore. The liquid is removed in a pipe 4, and a pump 5 pumps it up to the surface or onto shore as for the gas.

Figure 2 shows a similar installation to that in Figure 1. However, in addition to gas and oil, the separator here also separates out water that is fed via a pipe 6 to a pump 7 and back to the reservoir.

Figure 3 shows a sea bed installation designed for conditions with a lot of gas in relation to liquid. The solution is like that in Figure 1 but the liquid (oil and water) that is separated out in a first separator 1 is fed to a second separator 8 where the oil is fed to the surface via the pipe 4 and the pump 5, while the water is reinjected by means of the pump 7 via the pipe 6.

Figure 4 shows a sea bed processing plant designed for heavier oils and represents a further development of the installation shown in Figure 3. The pipe separator 1, which, in this case, is designed for gas/oil/water separation, is connected to the well head 2. The gas is removed in the pipe 3 and fed to the surface. The oil and water proceed to a compact electrostatic coalescer (CEC) 9 that increases the drop size of the water. The oil and water are then separated in a second pipe separator 8 for oil/water separation. The oil is removed in the pipe 4 and pumped to the surface by the oil pump 5, while the water is reinjected via the pipe 6 and the reinjection pump 7.

Figure 5 shows a sea bed installation that, in addition to that which is shown in Figure 4, has a gas dehydration unit. The gas that is separated out in the first separator 1 is fed first to a gas dehydration reactor 11. Here, glycol is added that "reacts with" the water in the gas. The gas and the liquid (water dissolved in glycol) are then fed to a third separator 12, which, in turn, separates out the gas, which is fed to the surface via a pipe 14, while the liquid is fed to a pump 16 and on to the surface.

Figure 6 shows an example based on the solution shown in Figure 4, but which is adapted for a situation in which different quantities of oil, gas and water are produced in different ratios from two or more wells. From well 2, oil/gas/water are separated in a first separator 1 and oil/water in a second separator 12 with an intermediate coalescer 9, as explained previously.

Down-hole separation takes place in a second well 20. Water separated out from the first separator 2, the second separator 12 and the down-hole separator 18 is fed via

respective pipes 21, 22, 23 to a buffer tank 18 for reinjection water. The water in the tank 18 is reinjected into the reservoir by means of a pump 19 via the pipe/well 6.

The present invention, as it is shown and described in the present application, offers several advantages:

1. The pipe separator tolerates high internal and external pressure and therefore allows the following processing tasks to take place at large sea depths:
    - Bulk gas/oil/water or oil/water separation.
    - Removal of water from crude oil to product specifications.
        * A pipe separator in combination with a Compact Electrostatic Coalescer (Kværner technology).
        * A pipe separator in combination with a Pect C Coalescer (Cyclotech technology).
    - Gas dehydration by means of a combination of gas dehydration technology (Minox technology) and a pipe separator.
2. It produces a quality of aqueous phase that allows reinjection.
3. Low water content in the oil and gas flows, thus allowing chemical-free hydrate control in connection with transport to downstream installations.
4. The pipe separator tolerates a high internal process pressure and can therefore be installed to advantage upstream of a choke valve on the well head.

   The high process pressure will improve the phase separation properties and allow reduced use of de-emulsifier or chemical-free separation, depending on the fluid properties.
5. For fields with acid oil and the potential for calcium naphthenate precipitation, sea bed processing with removal of water to 0.5%, performed at a high system pressure (i.e. lower pH in the aqueous phase on account of more CO in the aqueous phase), will eliminate problematic precipitation of calcium naphthenate or expensive topside installations designed to handle calcium naphthenate precipitation.

Claims

1. An installation arranged on the sea bed for the separation of fluids, comprising at least one separator (1) that is connected to one or more wells, each via an associated well head (2) or similar, and a pipeline, in which the components separated, oil, gas, water or combinations of these substances, are fed fully or partially from the installation to a platform, vessel, etc. on the surface or via collecting pipelines onto shore, or are reinjected into the formation beneath the sea bed,

   c h a r a c t e r i s e d i n t h a t

   each separator (1) consists of a long pipe (pipe separator) that may form a major or minor part of the transport pipeline (18) from the well and has a diameter that is mainly equal to or slightly larger than the diameter of the transport pipeline (18).

2. An installation in accordance with claim 1,

   c h a r a c t e r i s e d b y

   a first separator (1), which is designed to separate gas and liquid, where the gas separated is fed via a pipeline (3) to the surface/shore, while the liquid separated is fed to a second pipe separator (8) for oil and water, after which the oil separated is fed to the surface/shore via a pump (5) and pipeline (4), while the water separated is reinjected into the reservoir by means of a pump (7) via a pipeline (6).

3. An installation in accordance with claims 1 and 2,

   c h a r a c t e r i s e d i n t h a t

   a compact electrostatic coalescer (9) is arranged between the first and second pipe separators (1 and 3).

4. An installation in accordance with claims 1-3,
characterised in that
a gas dehydration unit (11) and a subsequent gas/liquid separator (12) are arranged at the gas outlet from the first separator (11), whereby glycol is added via a pipeline (13) to the dehydration unit (11), while gas separated is fed from the separator (12) to the surface via a pipeline (14) and glycol separated is fed to the surface by means of a pump (16) via a pipeline (15).

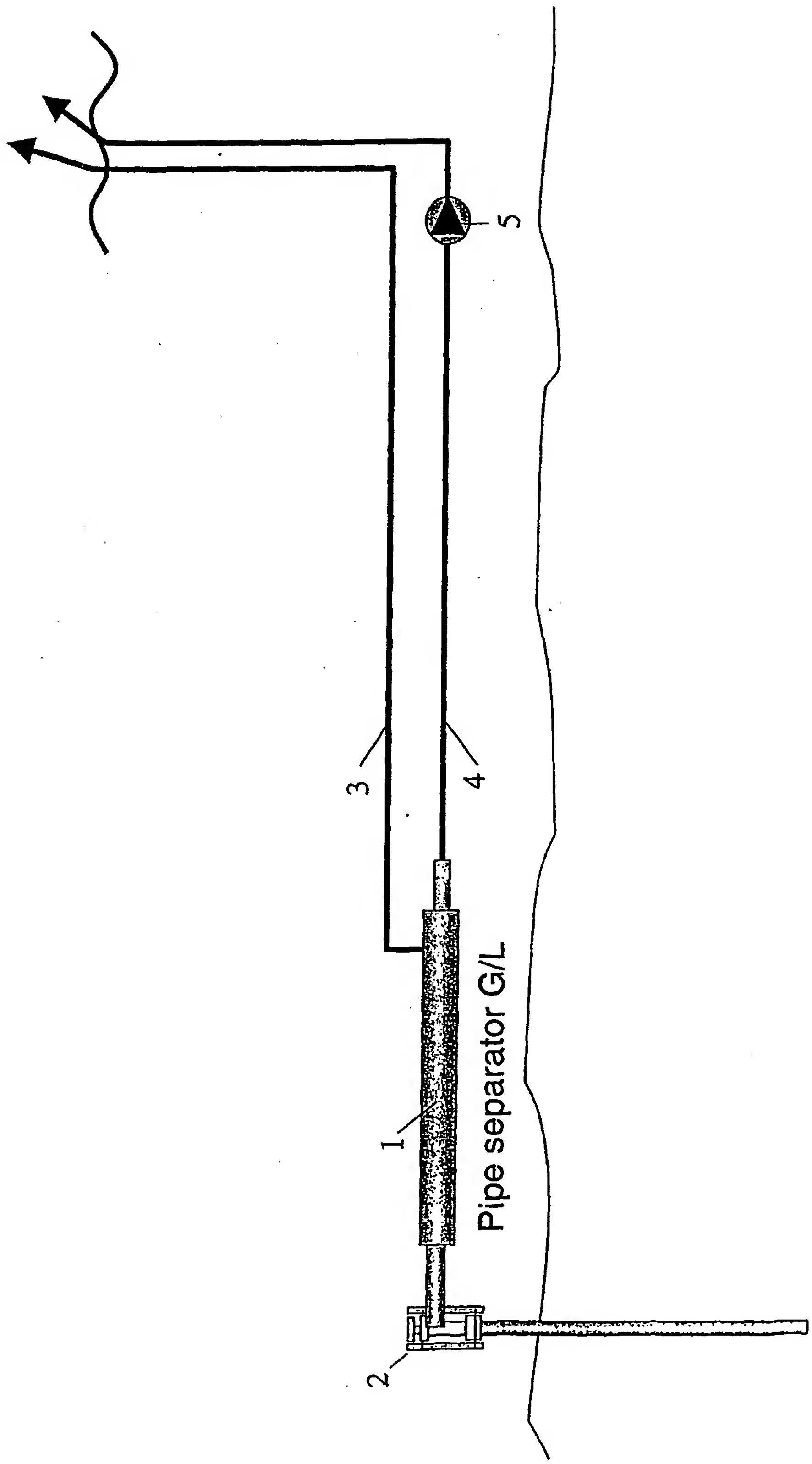

Fig. 1

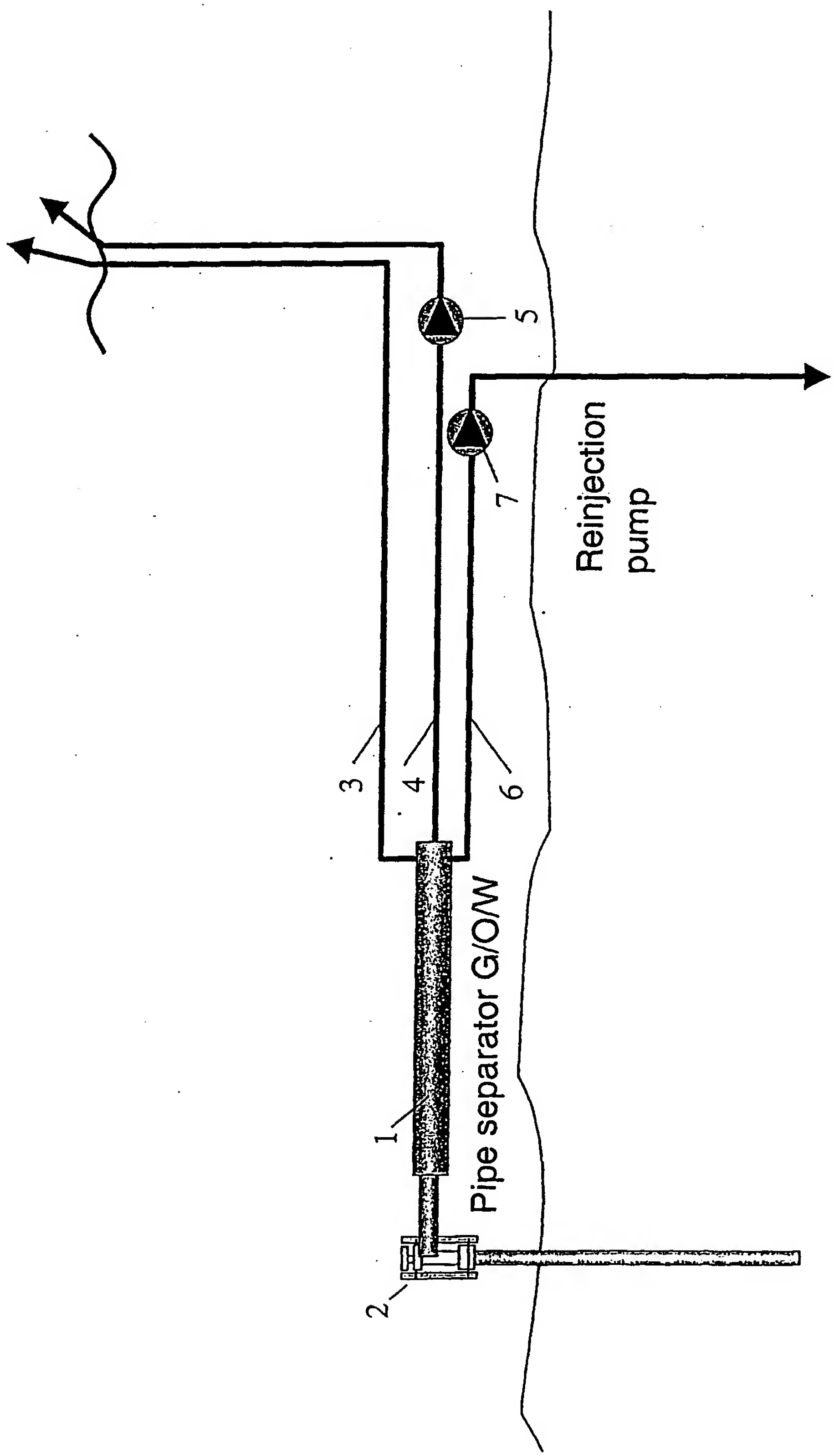

Fig. 2

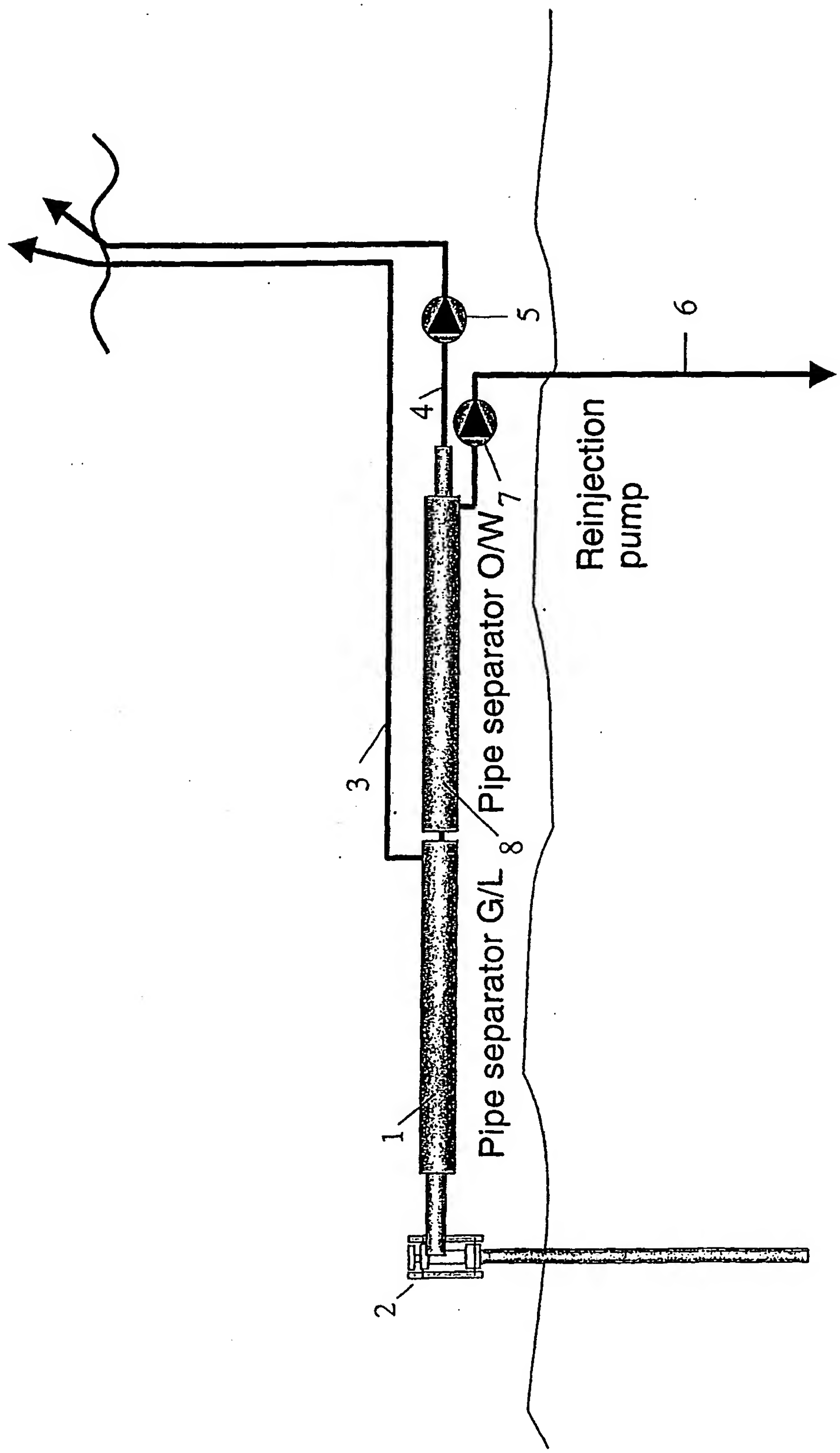
Pipe separator G/L
Pipe separator O/W
Reinjection
pump
1
2
3
4
5
6
7
8

Fig. 3

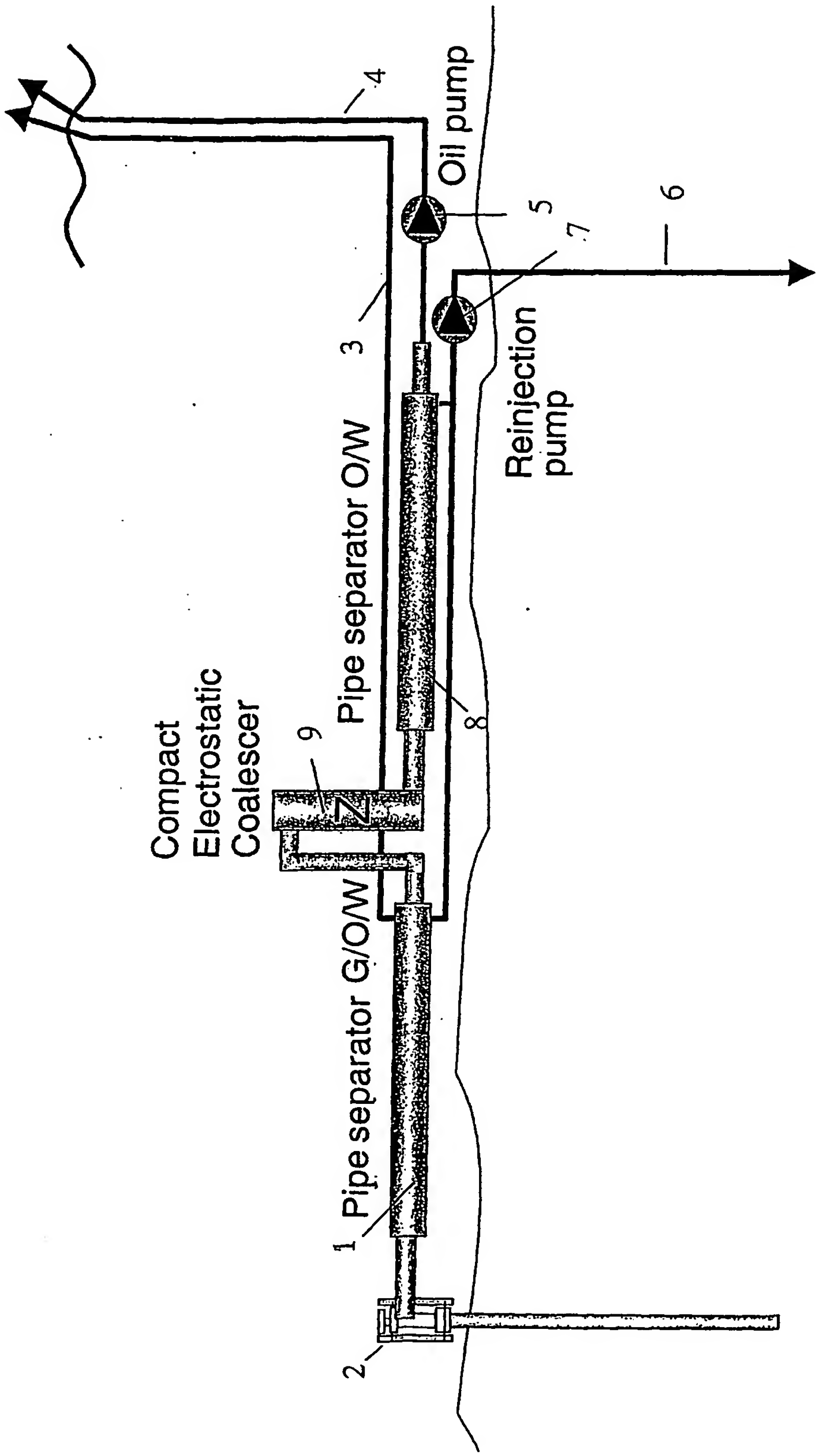
Oil pump
Reinjection pump
Pipe separator O/W
Compact Electrostatic Coalescer
Pipe separator G/O/W
1
2
3
4
5
6
7
8
9

Fig. 4

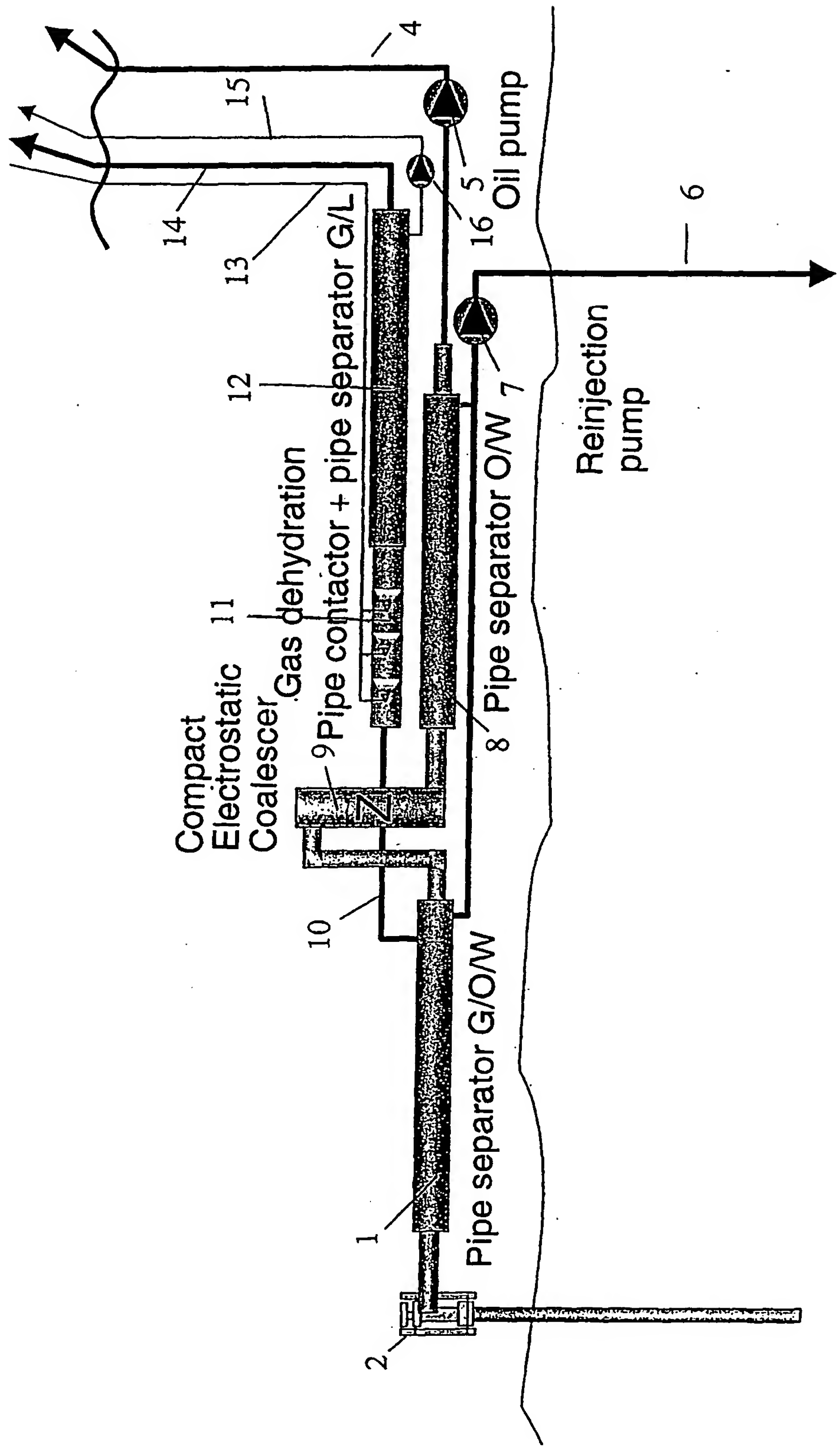
4
15
14
13
12
11
10
9
8
7
6
5
16
1
2
Oil pump
Reinjection pump
Gas dehydration
Pipe contactor + pipe separator G/L
Compact Electrostatic Coalescer
Pipe separator O/W
Pipe separator G/O/W

Fig. 5

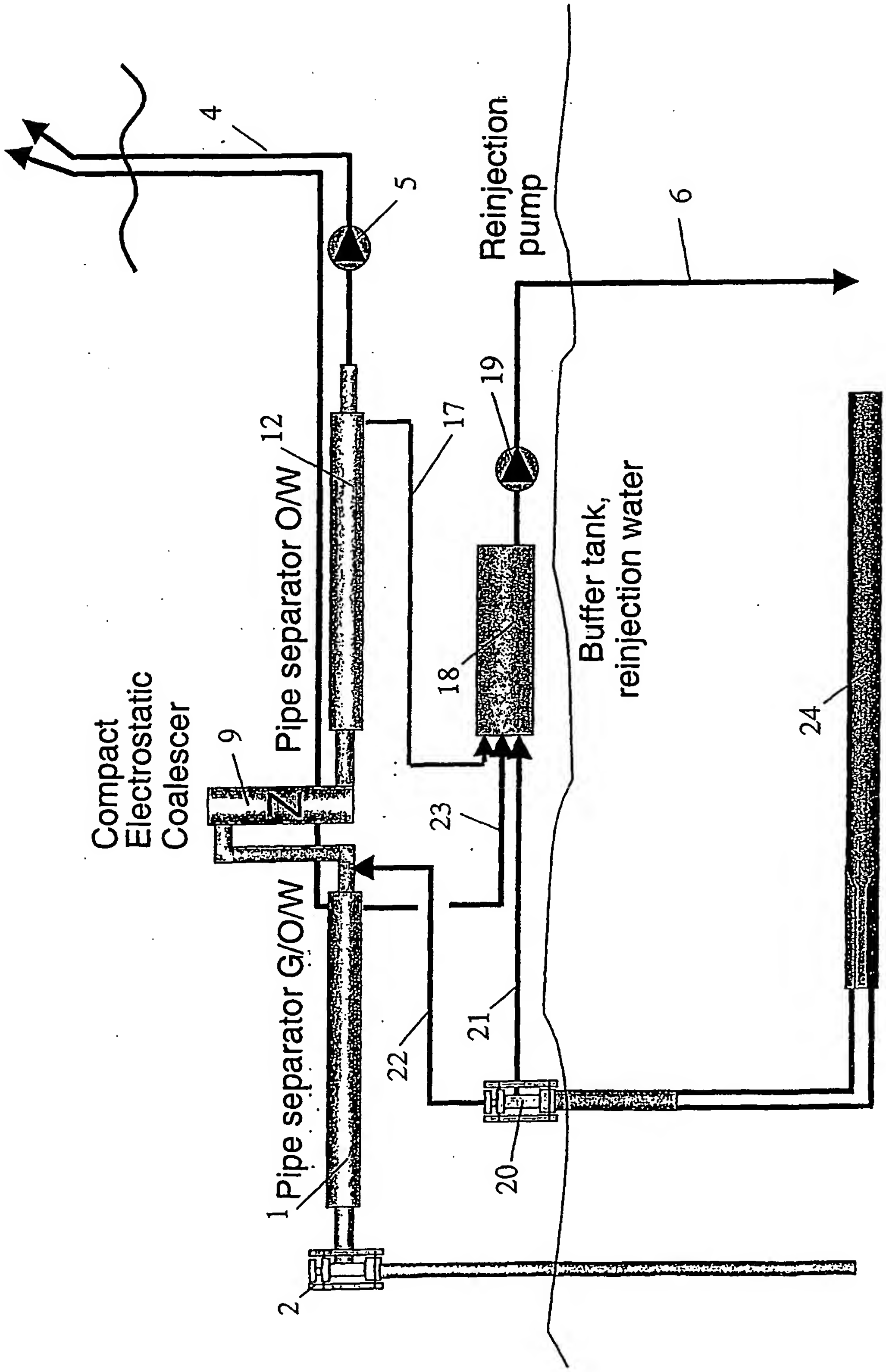
Compact
Electrostatic
Coalescer
Pipe separator O/W
Pipe separator G/O/W
Pipe separator
Reinjection
pump
Buffer tank,
reinjection water
1
2
4
5
6
9
12
17
18
19
20
21
22
23
24

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 02/00370

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: E21B 43/36
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: E21B, B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 0100296 A1 (DEN NORSKE STATS OLJESELSKAP A.S.), 4 January 2001 (04.01.01), the claims; the figures	1,3
Y		2,4
	--	
Y	US 6277286 B1 (T. SONTVEDT ET AL), 21 August 2001 (21.08.01), the claims	2
	--	
Y	US 6010674 A (B.B. MILES ET AL), 4 October 2000 (04.10.00), the whole document	4
	--	
X	WO 9503868 A1 (KVAERNER PALADON LIMITED), 9 February 1995 (09.02.95)	1
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 January 2003	20-01-2003
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Christer Bäcknert / MRo Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 02/00370

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 0008302 A1 (KVAERNER PROCESS SYSTEMS A.S. ET AL), 17 February 2000 (17.02.00) --	1-4

INTERNATIONAL SEARCH REPORT
Information on patent family members

30/12/02

International application No.
PCT/NO 02/00370

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		GB 2374031 A	09/10/02
		GB 9816725 D	00/00/00
		NO 20010436 A	22/03/01